

**Claims:**

Sub A1 1. A method of detecting a predetermined mark embedded in an image, said mark comprising a predetermined arrangement of a plurality of elements, each element having  
5 a predetermined colour characteristic and predetermined shape, the method comprising the steps of:

processing the image to provide an encoded representation of the image at a predetermined resolution;

10 detecting coordinate positions for substantially each of said elements of the mark embedded in the image, wherein the detection is characterised by applying at least one mask to substantially each pixel of the encoded representation;

determining from said coordinate positions a set of spatial features representing a spatial arrangement of the detected elements; and

15 comparing the determined set of spatial features to a known set of spatial features to provide a confidence level measure for a degree of matching between the known set and the determined set of spatial features.

2. The method of claim 1, wherein the spatial features are features indicating an angular distribution about a predetermined origin for each mark.

3. The method of claim 2, wherein the features indicating said angular distribution comprise a signature indicating a discrete angular distribution about said origin.

Sub A2 4. Apparatus for detecting a predetermined mark embedded in an image, said mark comprising a predetermined arrangement of a plurality of elements, each element having  
25 a predetermined colour characteristic and predetermined shape, the apparatus comprising:

processing means for processing the image to provide an encoded representation of the image at a predetermined resolution;

30 detecting means for detecting coordinate positions of substantially each of said elements of the mark embedded in the image, wherein the detection is characterised by applying at least one mask to substantially each pixel of the encoded representation;

spatial feature determining means for determining a set of spatial features representing a spatial arrangement of the detected elements; and

comparison means for comparing the determined set of spatial features to a known set of spatial features and outputting a confidence level measure for a degree of matching between the known set and the determined set of spatial features.

5 5. Apparatus according to claim 4, wherein the spatial feature determining means comprises angular distribution means for determining an angular distribution of said mark elements about a predetermined origin for each mark.

6. Apparatus according to claim 5, wherein the features indicating said angular  
10 distribution comprise a signature indicating a discrete angular distribution about said origin.

7. Apparatus according to claim 6, wherein the signature comprises a plurality of  
15 radial signatures, each said radial signature indicating a discrete angular distribution of each element in a predetermined annular region encircling said origin.

8. Apparatus according to claim 6, wherein said comparison means compares a signature of the determined spatial feature with a corresponding signature of a known mark.

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9. A computer program product including a computer readable medium having  
recorded thereon a computer program for detecting a predetermined mark embedded in an image, said mark comprising a predetermined arrangement of a plurality of elements, each element having a predetermined colour characteristic and predetermined shape, the  
25 computer program product comprising:

processing means for processing the image to provide an encoded representation of the image at a predetermined resolution;

30 detecting means for detecting coordinate positions of substantially each of said elements of the mark embedded in the image, wherein the detection is characterised by applying at least one mask to substantially each pixel of the encoded representation;

spatial feature determining means for determining a set of spatial features representing a spatial arrangement of the detected elements; and

35 comparison means for comparing the determined set of spatial features to a known set of spatial features and outputting a confidence level measure for a degree of matching between the known set and the determined set of spatial features.

10. A computer program product according to claim 9, wherein the spatial feature determining means comprises angular distribution for determining an angular distribution of said mark elements about a predetermined origin for each mark.

11. A computer program product according to claim 10, wherein the features indicating said angular distribution comprises a signature indicating a discrete angular distribution about said origin.

12. A computer program product according to claim 11, wherein the signature comprises a plurality of radial signatures, each said radial signature indicating a discrete angular distribution of each element in a predetermined annular region encircling said origin.

13. A computer program product according to claim 11, wherein said comparison means compares a signature of the determined spatial feature with a corresponding signature of a known mark.

14. Apparatus for providing an encoded representation of image data, said image data comprising a plurality of pixels, each said pixel being represented using multiple colour channels, said apparatus comprising:

pixel buffer pipe means, having an input means for receiving said image data in a predetermined order and for detecting transitions between foreground and background pixels;

a pixel selection means for subsampling said image data in a first direction in accordance with an intensity of one said colour channel of the image data to provide a first desired resolution in said first direction;

foreground density checking means for receiving said one colour channel and outputting:

- a) if an intensity value of one said colour channel is below a first predetermined threshold value, a first token;
- b) if the intensity value of said one colour channel is above a second predetermined threshold value, a second token; or
- c) if the intensity value of said one colour channel is intermediate the first and second threshold values:

ca) the first token when a transition is detected at the pixel buffer pipe means; and

cb) the second token when a transition is not detected at the pixel buffer pipe means;

5 encoding means for receiving at least one other of said colour channels and selectively grouping each pixel represented in said at least one other colour channel into one group of a plurality foreground colour groups if the output of said foreground density checking means is the first token and grouping into a background colour group if the output of said foreground density checking means is the second token, said encoding  
10 means outputting for each pixel a representation of the corresponding group; and

output buffer means for receiving said representation and providing a subsampling in a second direction of the image data to achieve a second desired resolution in said second direction.

15 15. Apparatus according to claim 14, wherein further comprising subsample control means for further subsampling in said second direction according to a magnification value and an input resolution value.

20 16. Apparatus according to claim 14, wherein said transition is determined by the pixel buffer pipe means using lead pixels and lag pixels.

17. Apparatus according to claim 14, wherein said predetermined order comprises a raster scan order.

25 18. Apparatus according to claim 17, wherein said transition is a transition from background pixel to foreground pixel.

19. Apparatus according to claim 14, wherein said first and second desired resolutions are substantially the same resolution.

30 20. A method for providing an encoded representation of image data, said image data comprising a plurality of pixels, each said pixel being represented using multiple colour channels, the method comprising the steps of;

35 inputting pixels in a predetermined order and detecting transitions between foreground and background pixels;

Subsampling in a first direction of the image data in accordance with an intensity of one said colour channel of the image data to provide a first desired resolution in said first direction;

examining said one colour channel and outputting:

- 5           a)       if an intensity value of said one colour channel is below a first predetermined threshold value, a first token;
- b)       if the intensity value of said one colour channel is above a second predetermined threshold value, a second token; or
- 10          c)       if the intensity value is intermediate the first and second threshold values:
- ca)     the first token when a transition is detected upon inputting said pixels; and
- cb)     the second token when a transition is not detected upon inputting said pixels;

15           encoding each said pixel by selectively grouping each said pixel represented in at least one other of said colour channels into one group of a plurality foreground colour groups if said examining step outputs a first token and grouping into a background colour group if said examining step outputs a second token, and outputting for each pixel a representation of the corresponding group; and

20           subsampling in a second direction of the image data to achieve a second desired resolution in said second direction.

21.       A method according to claim 20, wherein said transition is determined using lead pixels and lag pixels.

22.       A method according to claim 20, wherein said foreground pixel is a pixel having a colour value belonging to a predetermined set colour values and the background pixel is a pixel which is not a foreground pixel.

23.       A method according to claim 20, wherein said predetermined order is raster scan order.

24.       A method according to claim 20, wherein said transition is a transition from background pixel to foreground pixel.

25. A method according to claim 20, wherein said transition is a transition from background pixel to foreground pixel.

26. A computer program product including a computer readable medium having recorded thereon a computer program for providing an encoded representation of image data, said image data comprising a plurality of pixels, each pixel being represented using multiple colour channels, the computer program product comprising;

pixel buffer pipe means, having an input means for receiving said image data in a predetermined order and for detecting transitions between foreground and background pixels;

pixel selection means for subsampling said image data in a first direction in accordance with an intensity of one said colour channel of the image data to provide a first desired resolution in said first direction;

foreground density examining means for receiving said one colour channel and outputting:

a) if an intensity value of said one colour channel is below a first predetermined threshold value, a first token;

b) if the intensity value of said one colour channel is above a second predetermined threshold value, a second token; or

c) if the intensity value of said one colour channel is intermediate the first and second threshold values:

ca) the first token when a transition is detected at the pixel buffer pipe means; and

cb) the second token when a transition is not detected at the pixel buffer pipe means;

encoding means for receiving at least one other of said colour channels and selectively grouping each pixel represented in said at least one other colour channel into one group of a plurality foreground colour groups if the output of said foreground density examining means is a first token and grouping into a background colour group if the output of said foreground density checking means is a second token, said encoding means outputting for each pixel a representation of the corresponding group; and

output buffer means for receiving said representation and providing a subsampling in a second direction of the image data to achieve a second desired resolution in said second direction.

27. A computer program product according to claim 26, wherein said transition is determined by the pixel buffer pipe means using lead pixels and lag pixels.

28. A computer program product according to claim 26, wherein said first and second desired resolutions are substantially the same resolution.

29. An apparatus for processing digital data, said apparatus comprising:  
an array of logic cells, each said cell being individually configurable to provide a plurality of functions;

10 a pipeline register, having a plurality of input means for receiving said digital data and for pipelining said data through said array of logic cells;

a plurality of logic gates for detecting a desired pattern of digital data, and for enabling each said logic cell to perform a configured one of said functions on said digital data.

15 30. Apparatus according to claim 29, wherein the desired pattern is provided by said function configured logic cells.

31. Apparatus according to claim 29, wherein said pipeline register comprises a plurality of flip-flop circuits in a matrix arrangement which forms a pipeline shift register.

32. Apparatus according to claim 31, wherein said logic gates clear selected one of said flip-flops via said logic cells when a predetermined pattern is detected.

25 33. Apparatus according to claim 32, wherein said predetermined pattern is determined by the configuration functions and the arrangement of said flip-flop matrix and said logic cells.

34. Apparatus for detecting a predetermined pattern forming part of an image, said image comprising a plurality of pixels, each said pixel being encoded either as a foreground or background pixel, said predetermined pattern being intended to substantially match a predetermined reference pattern, the reference pattern being represented by a mask arranged as a two dimensional array of cells, the cells having indicated thereon whether the reference pattern comprises foreground pixels, background pixels or neither, said apparatus comprising:

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input means for receiving a plurality of one dimensional arrays of pixel values of said image, wherein each said array being received sequentially;

foreground adder means for generating a plurality of partial sums of said foreground pixels, for each array of pixel values, intended to match with the reference pattern of the mask, wherein each partial sum of said foreground pixels substantially corresponds to an application of a slice of said mask;

background adder means for generating a plurality of partial sums of said background pixels, for each array of pixel values, intended to match with the reference pattern of the mask, wherein each partial sum of said background pixels substantially corresponds to the application of said slice;

a foreground accumulator network for providing a total foreground count value of said plurality of partial sums for a predetermined number of input arrays of pixel values;

a background accumulator network for providing a total background count value of said plurality of partial sums for the predetermined number of input arrays of pixel values;

thresholding means for thresholding the total foreground count value and the total background count value against first and second predetermined threshold values respectively and outputting a value reflecting each threshold comparison; and

determining means for determining from each output value whether or not the predetermined pattern is detected.

35. Apparatus according to claim 34, wherein said image comprises a plurality of scan lines, each said scan line having a plurality of pixel values and said one dimensional array comprises a predetermined number of pixel values of corresponding locations on a plurality of adjacent scan lines.

36. Apparatus according to claim 34, wherein said apparatus forms a pipeline circuit for pipelining the sequence of one dimensional arrays.

37. A method of detecting a predetermined pattern forming part of an image, said image comprising a plurality of pixels, each said pixel being encoded either as a foreground or background pixel, said predetermined pattern substantially matching a predetermined reference pattern, the reference pattern being representable by a mask arranged as a two dimensional array of cells, each cell having indicated thereon whether



the cell is a foreground pixel, background pixel or neither, the method comprising the steps of:

providing a plurality of one dimensional arrays of pixel values of said image, wherein each array is provided sequence;

5 generating a plurality of partial sums of foreground pixels for a current one dimensional array of pixel values which match with foreground cells of the reference pattern of a slice of the mask;

generating a plurality of partial sums of background pixels for the current one dimensional array of pixel values which match with background cells of the reference pattern of said slice of the mask;

10 accumulating the partial sums of foreground pixels for a predetermined number of input one dimensional arrays of pixel values to provide a total foreground count value;

accumulating the partial sums of background pixels for a predetermined number of input one dimensional arrays of pixel values to provide a total background count value;

15 thresholding the total foreground count value and the total background count value against a first and second predetermined threshold value respectively and outputting a value reflecting each threshold comparison; and

determining from each output value whether or not the predetermined pattern is detected.

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38. A method according to claim 37, wherein said foreground pixels are pixels having one colour selected from a first set of colour values and said background pixels are pixels having one colour selected from a second predetermined set of colour values.

25 39. A method according to claim 37, wherein each cell of the slice of the mask corresponds with a pixel value of the one dimensional array.

40. A method of detecting a predetermined pattern forming part of an image, said image comprising a plurality of pixels, each said pixel being either on or off, said predetermined pattern substantially matching a predetermined reference pattern, the reference pattern being representable by a mask arranged as a two dimensional array of cells, each cell having indicated thereon whether the cell is on or off, the method comprising the steps of:

35 providing a plurality of one dimensional arrays of pixel values of said image, wherein each array is provided sequence;

generating a plurality of partial sums of on pixel values for a current one dimensional array of pixel values which match with an on cell of the reference pattern of a slice of the mask;

accumulating the partial sums for a predetermined number of input one dimensional arrays of pixel values; and

thresholding the accumulated partial sums against a predetermined threshold value and determining whether or not the predetermined pattern is detected based on the threshold comparison.

41. A computer program product including a computer readable medium having recorded thereon a computer program for detecting a predetermined pattern forming part of an image, said image comprising a plurality of pixels, each said pixel being encoded either as a foreground or background pixel, said predetermined pattern substantially matching a predetermined reference pattern, the reference pattern being represented by a mask arranged as two dimensional array of cells, the cells having indicated thereon whether the reference pattern is foreground pixel, background pixel or neither, the computer program product comprising:

input means for receiving a plurality of one dimensional arrays of pixel values of said image, wherein each array is received sequentially;

foreground adder means for generating a plurality of partial sums of foreground pixels, for each array of pixel values, which match with the reference pattern of the mask, wherein each partial sum substantially corresponds to an application of a slice of said mask;

background adder means for generating a plurality of partial sums of background pixels, for each array of pixel values, which match with the reference pattern of the mask, wherein each partial sum of background pixels substantially corresponds to the application of said slice;

a foreground accumulator network for providing a total foreground count value of said plurality of partial sums for a predetermined number of input arrays of pixel values;

a background accumulator network for providing a total background count value of said plurality of partial sums for the predetermined number of input arrays of pixel values;

thresholding means for thresholding the total foreground count value and the total background count value against a first and second predetermined threshold value respectively and outputting a value reflecting each threshold comparison; and

5 determining means for determining from each output value whether or not the predetermined pattern is detected.

42. A computer program product according to claim 41, wherein said image comprise a plurality of scan lines, each scan line having a plurality of pixel values and said one dimensional array comprises a predetermined number of pixel values of  
10 corresponding locations on a plurality of adjacent scan lines.

43. A computer program product according to claim 41, wherein said foreground pixels are pixels having one colour selected from a first set of colour values and said background pixels are pixels having one colour selected from a second predetermined set  
15 of colour values.

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